CHAPTER 15

Operations Strategies

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Highways are traditionally viewed as transportation facilities with fixed capacity, carrying traffic that peaks with commuters twice each weekday. Available capacity, however, is highly dynamic; it can be reduced by the actions of individual drivers or by severe weather. Within the confines of available capacity, traffic flow can be improved by implementing different types of operational strategies.

Traffic demand does not only peak twice daily during morning and afternoon "rush hours," but peaks throughout the day, week, and season for many reasons. Some traffic variability is recurring and predictable, but capacity constraints can be driven by temporary and less predictable events. The negative consequences of both predictable and unpredictable variations can be minimized with advanced traffic control systems, timely responses to incidents, and other highway operations strategies. This chapter highlights the variability in traffic demand and highway capacity and examines the operations strategies used by highway agencies to maximize the highway system in the face of this variability.

Dynamic Traffic and Capacity

The traditional view is that traffic demand and highway capacity are relatively static, with traffic volumes increasing in morning and afternoon peak periods each weekday and congestion occurring when the fixed capacity of the highway system is exceeded. This view ignores the large volume of nonwork trips, the volume of freight movements, and the impact on these trips caused by the actions summarized in *Exhibit 15-1.*

Chapter 4 documents the spread of "rush hour" commuting periods to greater shares of each day in cities of all sizes. Other peaks in traffic demand because of weekend shopping, seasonal recreational travel, freight activity, and large events such as professional sports are less well measured, but probably account for an increasing share of congestion and delay as trips to work become a smaller percentage of total travel.

Exhibit 15-1

Sources of Congestion

Peaks in Demand	Recurring weekday commuting in urban areas Recurring weekend shopping in urban areas Seasonal vacation travel on rural and intercity highways Major generators of freight traffic (ports, factories, distribution centers) Large events (sporting venues, concerts, disasters)
Capacity Limitations	Network extent and coverage Bottlenecks (interchanges and intersections, converging lanes, steep slopes, sharp turns) Impediments (toll booths, border crossings, truck inspection stations) Poor traffic control (traffic signal coordination) Traffic calming
Temporary Capacity Reductions	Crashes and breakdowns Work zones Weather Street closures for events (parades, street fairs, marathons, disasters) Rail-highway grade crossings Temporary curb-side obstructions (especially curb-side parking and construction adjacent to rights-of-way) Law enforcement actions

Any peaks in traffic volume can overwhelm the maximum design capacity of a highway system. Bottlenecks such as interchanges, converging lanes, tollbooths, vehicle inspection stations, or poor traffic control can all adversely affect throughput.

Delays resulting from the lack of capacity to accommodate weekday peaks in commuting are captured by the operations performance measures presented in Chapter 4, as well as in the future investment scenarios presented in Chapter 7 and developed using the Highway Economic Requirements System (HERS) model. The HERS model is not as robust in estimating delays from bottlenecks, which have been analyzed independently by the American Highway Users Alliance. Its recent study, *Unclogging America's Arteries: Effective Relief for Highway Bottlenecks, 1999–2004,* identified 233 major bottlenecks, a substantial increase over the 167 major bottlenecks it identified just 5 years earlier.

Traffic cannot always take advantage of the maximum capacity of a highway. Reductions in maximum capacity caused by crashes, work zones, bad weather, and other incidents create at least as much delay as the recurring overload of traffic from commuting. Half of the delay reported by the Texas Transportation Institute and cited in Chapter 4 is attributed to incidents alone. Based on a composite of estimates by the Texas Transportation Institute and Oak Ridge National Laboratory, crashes and breakdowns account for about 40 percent of congestion delay, recurring congestion resulting from daily commuting is responsible for approximately 35 percent, work zones account for over 15 percent, and bad weather and poor signal timing account for most of the balance. Cambridge Systematics has developed similar estimates showing bottlenecks creating 40 percent of delay, incidents causing 25 percent, bad weather accounting for 15 percent, and work zones creating 10 percent, with signal timing responsible for approximately half of the remaining balance. Temporary capacity losses due to work zones, crashes, breakdowns, adverse weather, sub-optimal signal timing, toll facilities, and railroad crossings caused over 3.5 billion vehicle-hours of delay on U.S. freeways and principal arterials in 1999, adding over four hours of delay per 1,000 miles of travel in addition to delay from recurring congestion.

The traveling public, shippers, and carriers are affected by the dynamic fluctuations in traffic and capacity because these fluctuations translate into delay and cost. As noted in Chapter 14, unexpected delay from temporary capacity loss causes unpredictable travel and arrival times. This situation is especially costly to the freight transportation community and affects the economy and the American consumer. To overcome constraints on maximum capacity and temporary capacity losses, operations strategies are a critical tool.

In addition to mitigating congestion and expanding existing capacity, operations strategies are needed to enhance the safety and security of the transportation system. Crashes, natural disasters, and other threats to life and property must be quickly identified and appropriate responses mobilized. Disruptions to normal traffic flow, such as work zones and bad weather, are as much a safety problem as a source of delay. Congestion and safety problems may be aggravated by the presence of poor traffic control, inadequate signage, and ineffective traveler information systems.

Types of Operations Strategies

As summarized in *Exhibit 15-2,* highway operations strategies can influence the reliability, efficiency, safety, and security of highway use by responding to fluctuations in traffic demand. Several major operations strategies used to address these conditions are highlighted here and discussed in greater length in a report prepared for the Federal Highway Administration (FHWA) by Cambridge Systematics, Inc., *Traffic Congestion and Reliability: Linking Solutions to Problems.*

Exhibit 15-2

Traveler Problems and Operational Responses

What does the traveling public want?	What gets in the way of what the traveling public wants?	What can traffic managers do about it?
Reliability (reliable, predictable travel time)	Special events Work zones Bad weather Vehicle crashes and breakdowns Double-parked vehicles Lack of information on route conditions and alternatives	Reroute traffic or adjust lanes and traffic control Snow and ice removal Incident response vehicles Parking management Traveler information on disruptions and alternatives
Timeliness	**All of the above plus:** Daily and seasonal peaks of heavy traffic Bottlenecks and impediments Poorly coordinated traffic control	**All of the above plus:** Adaptive signal control Ramp meters Reversible lanes Electronic toll collection Curbside parking management Adjustments to carrier schedules
Safety	Vehicle crashes and breakdowns Work zones Bad weather Poor facility design and traffic control Driver behavior Poor facility design and traffic control Poor physical condition of facilities	Detect and respond to crashes Traveler information on location of crashes and problem areas and on alternative routes Emergency medical services Driver education Better signage and markings Identify and correct unsafe conditions
Security	Property theft Personal assaults Military logistics Terrorism Regional disasters	Visible monitoring as a deterrence Reroute traffic or adjust lanes and traffic control Detect and respond to threats and incidents Identify and correct unsafe conditions Threat assessments and countermeasures and disaster response plans Traveler information

Effective operation of freeways and other major arterials includes monitoring roadway conditions; detecting, verifying, responding to, and clearing incidents quickly; identifying recurring and nonrecurring traffic bottlenecks; providing travel condition information; implementing lane management strategies; controlling flows onto freeways with ramp meters; and restricting some facilities to high occupancy vehicles (HOV). In addition, on minor arterials and major collectors, the timing and coordination of traffic signals are essential to facilitate the flow of traffic.

The operations strategy of access management can be implemented in many different manners and, therefore, can be used to optimize highway performance on all types of roads. One approach, access spacing, increases the distance between traffic signals on major arterials. This improves the flow of traffic, thereby reducing congestion and its effects. Driveway spacing restricts the number of driveways and spaces them farther apart, allowing a more orderly merging of traffic with fewer conflicts for drivers. Dedicated left- and right-turn lanes, indirect left-turns and U-turns, and roundabouts are other useful ways to keep through traffic flowing. Median treatments, such as two-way left-turn lanes and nontraversable raised medians, are effective in regulating access and reducing the number of crashes.

Q&A

How do intelligent transportation systems relate to operations strategies?

Intelligent transportation systems (ITS) include a wide range of advanced technologies used to manage highway transportation and public transit, such as electronic toll payment, roadway surveillance systems, and advanced traveler information systems. Such systems are being used around the country to improve the operational efficiency and safety of the transportation system. The impetus to employ ITS is growing as technology improves, congestion increases, and building new roads and bridges becomes more difficult and expensive.

ITS technologies are being deployed to actively manage freeways and arterials in many places around the country. For instance, ramp metering on freeways is used to regulate the flow of traffic entering a facility to increase vehicle throughput and speeds. In the Minneapolis-St. Paul region, ramp metering increased vehicle throughput by 30 percent and average speeds in the peak period by 60 percent. Adaptive signal control is another type of ITS that adjusts traffic signal timing based on current traffic demand. In Los Angeles, where nearly 2,500 of the over 4,000 traffic signals use adaptive signal control, delay at intersections with these systems is reduced by an average of 10 percent.

Traveler information systems use a wide variety of ITS technologies to improve highway mobility and safety. These applications are currently being used in many different situations, including road weather information systems and in work zones and during special events. A traveler information system involving traffic cameras, remote traffic microwave sensors, dynamic message signs (DMS), and highway advisory radio is used in work zones on I-30 and I-40 in central Arkansas. In Montana, weather sensors and DMS are being used to warn motorists of high winds on portions of I-90.

In many places, a transportation management center (TMC) coordinates the use of ITS. A TMC is typically a central location for bringing together multiple agencies, jurisdictions, and control systems for managing traffic and transit, incident and emergency response, and traveler information. Transportation management technology includes closed-circuit television cameras, DMS, synchronized traffic signals, vehicle-flow sensors, highway advisory radio, and other high-tech devices. To manage emergencies, Houston TranStar uses a host of technologies in two of their ITS systems: the Road Flood Warning Systems and the Regional Incident Management System.

In addition to managing the supply of highways, agencies can affect travel demand. In the past, managing demand consisted of encouraging commuters to change their travel mode from driving alone to choosing a carpool, vanpool, public transit, or other commuter alternative. More recent transportation-demand management tools include providing express and shuttle bus services, guaranteed ride programs, transit-van integration programs, partnerships between transportation agencies and employers, and local land-use controls.

Another way of managing transportation demand is through real-time traveler information. Traveler information can affect demand by influencing the choices that people make about how, when, where, whether, and which way they travel to their destinations. Information on traffic conditions, transit service, parking availability, and weather conditions is being delivered through Web sites, dynamic message signs, e-mail alerts, and highway advisory radio. States and metropolitan areas also are implementing 511, the telephone number dedicated by the Federal Communications Commission for relaying information to travelers.

Information is also critical to locating and clearing crashes, stalled vehicles, spilled loads, and other highway debris. Efficient and rapid response, effective management of resources at the incident, and area-wide traffic control all depend on the rapid exchange of accurate and clear information among the responding parties.

This requires communications standards and institutional coordination among police, fire, emergency medical services, tow truck firms, hazardous materials contractors, and TMCs.

Work zones are second only to incidents as a source of delay from temporary capacity loss. Effective work zone management requires fundamental changes in the way reconstruction and maintenance projects are planned, estimated, designed, bid, and implemented. A comprehensive approach to work zone management requires minimizing work zone consequences, serving the customer around the clock, making use of real-time information, and aggressively pursuing public information and outreach.

Adverse weather is the third most common source of delay from temporary capacity loss. Although the weather cannot be changed, its effects on highway safety and operations can be reduced. Today, it is possible to predict weather changes and identify threats to the highway system with much greater precision through the use of roadside weather-monitoring equipment linked to TMCs. More precise weather information can be used to adjust speed limits and traffic signal timing; pretreat roads with anti-icing materials; pre-position trucks for de-icing, sanding, or plowing; and inform travelers of changing roadway conditions.

Natural and man-made disasters can have a major impact on a transportation system. These place special demands on the system to bring responders to the scene, transport the ill and injured to medical facilities, and remove the public from potential harm. Effective response requires State and local agencies to cooperate on developing and updating plans and preparing for disasters.

Progress in Implementation

The FHWA monitors the progress in implementation of a number of operations strategies as a leading indicator of future operational performance.

Intelligent Transportation Systems (ITS)

ITS uses advanced technology to improve highway safety and efficiency. The progress of ITS deployment is shown in Chapter 2. In general, the deployment of ITS is increasing with real-time data collection sensors currently deployed on more than one-third of the total freeway mileage and on-call service patrols covering half of the freeway mileage. Substantial progress has been made in deploying integrated infrastructures between 1997 and 2005. The number of areas ranked in low category for ITS deployment decreased from 39 to 12, and the number ranked as high increased from 11 to 30 during this period. (See "Intelligent Transportation Systems" section of Chapter 2.)

Deployment of Regional Architectures

Regional ITS Architecture is a specific, tailored framework for ensuring institutional agreement and technical integration for the implementation of ITS projects or groups of projects in a particular region. It functionally defines what pieces of the system are linked to others and what information is exchanged between them. Of the 311 Regional Architectures identified as needed throughout the Nation, a total of 164, or more than 52 percent, were completed by the end of 2004.

Deployment of 511 Traveler Information Systems

The development and establishment of 511 Traveler Information Systems to provide access to highway and travel conditions in all parts of the Nation have been identified as key elements in the implementation of a

successful National operations strategy. The number of active 511 systems at the end of 2004 was 24 located in 21 States, providing access to over 70 million of the U.S. population, or approximately 25 percent.

Work Zone Self-Assessment

The Work Zone Self-Assessment (WZSA) tool is a set of questions designed to assist those with work zone management responsibilities in assessing their programs, procedures, and practices against many of the good work zone practices in use today. The WZSA consists of 46 questions divided into six primary assessment areas that have an effect on work zone management. The six primary areas are Leadership and Policy, Project Planning and Programming, Project Design, Project Construction and Operations, Communications and Education, and Program Evaluation.

Averaging the WZSA results across all the FHWA Divisions provides an indication of the state of the practice in work zone management nationwide. The national average score is based on a 1 to 10 scale, with 10 being highest. The score increased from 7.4 in 2003 to 8.2 in 2005.

Traffic Incident Management Self-Assessment

The Traffic Incident Management (TIM) Self-Assessment (SA) tool consists of a set of 33 questions designed to permit TIM program practitioners to assess the strengths and weaknesses of various components of the TIM programs. The assessment is designed to be conducted by a team consisting of TIM partners from transportation, public safety, and the private sector. The TIM SA is divided into three main sections: Programmatic and Institutional Issues, Operational Issues, and Communications and Technology Issues. Each of these sections has three subcomponents.

The Programmatic and Institutional components are Formal TIM Programs, TIM Administrative Teams, and Performance Measurement. The Operational Issues components are Procedures for Major Incidents, Responder and Motorist Safety, and Response and Clearance Policies and Procedures. The Communications and Technology components are Integrated Interagency Communications, Transportation Management Systems, and Traveler Information.

The national score is based on a scale from 0 percent to 100 percent. The score has increased from 45.9 percent in 2003 to 52.2 percent in 2005.

Congestion Partnerships Self-Assessment

The Congestion Partnerships Self-Assessment is used to establish a baseline from which to measure progress in the implementation of collaborative actions needed to address issues related to transportation operations on a region-wide basis. It is also used to identify gaps and provide an annual measure of the level of regional transportation operations collaboration and coordination within the 75 largest metropolitan areas and other significant areas where transportation safety, security, and reliability are significant regional concerns. It is also used in smaller metropolitan areas, freight corridors, national parks, and tourist areas.

Scoring is on a scale of 0 to 5 and involves five areas: structure, process, products, resources, and performance. A final assessment score is developed averaging the five scores for each metro area. The national average score is an average of the scores of the top 75 metro areas. The national score has increased from 2.0 in 2004 to 2.1 for 2005.

SAFETEA-LU and Operations

The Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) calls for the establishment of a real-time system management information program to provide capabilities to monitor real-time traffic and travel conditions on the Nation's major highways. It also directs this information is to be shared to improve the security of the surface transportation system, to address congestion problems, to support improved response to weather events and surface transportation incidents, and to facilitate national and regional highway traveler information. Additional methods to aid in the mitigation of congestion are the implementation of HOV facilities, accessing tolls, overall regional planning and operational agreements, use of exiting technology to provide access and dissemination of pertinent information, and increased safety for workers. A brief overview of these operations strategies is provided in the following subsections.

HOV Facilities and Tolling

Section 1121—HOV Facilities—Clarifies the operation of high occupancy vehicle (HOV) facilities and provides more exceptions to vehicle occupancy requirements, focusing on exemptions/certification for bicycles, motorcycles, and inherently low-emission vehicles (ILEV). States may also establish exceptions for public transportation vehicles, certified low-emission and energy-efficient vehicles, and high occupancy toll (HOT) vehicles. Tolls under this section may be charged on both Interstate and non-Interstate facilities.

Section 1604—Tolling—Extends and authorizes a total of $59 million funding for the Value Pricing Pilot Program; creates a new Express Lanes Demonstration Program to permit tolling on up to 15 demonstration projects to manage congestion, reduce emissions, or finance new lanes to reduce congestion on the highway system; and creates a new Interstate System Construction Toll Pilot Program that authorizes tolling to finance construction of up to three new Interstate highway facilities.

Planning and Agreements

Section 6001—Transportation Planning—Operations—Contains a number of elements that spell out the importance of management and operations in the planning process, including an important role in the Congestion Management Process in Transportation Management Areas (TMAs) where effective management and operation to address congestion management must be included.

Section 10204—Catastrophic Hurricane Evacuation Plans—Requires U.S. Department of Transportation and Department of Homeland Security Secretaries to coordinate with the Gulf Coast States and contiguous States to jointly review and assess Federal and State evacuation plans for catastrophic events impacting the Gulf Coast Region, and to submit to the Congress a report of their findings and recommendations. The *Report to Congress on Catastrophic Hurricane Evacuation Plan Evaluation* was released on June 1, 2006.

Section 5211—Multistate Corridor Operations—Encourages multistate cooperative agreements, coalitions, or other arrangements to promote regional cooperation, planning, and shared project implementation for programs and projects. The program will improve transportation management and operations along Interstate 95 corridor and enhance transportation systems management and operations.

System Information and Technology

Section 1201—Real Time System Management Information Program—Requires the establishment of a real-time system management information program to provide, in all States, the capability to monitor the traffic and travel conditions of the Nation's major highways and to share that information with State and local governments and the traveling public. The purpose of the program is to improve the security

of the surface transportation system, to address congestion problems, to support improved response to weather events and surface transportation incidents, and to facilitate national and regional highway traveler information.

The three purposes of the program are to (1) establish, in all States, a system of basic real-time information for managing and operating the surface transportation system; (2) identify longer-range real-time highway and transit monitoring needs and develop plans and strategies for meeting those needs; and (3) provide the capability and means to share the data with State and local governments and the traveling public.

The four anticipated results of the Real-Time System Management Information Program are (1) publicly available traveler information Web site(s) providing access to information that is derived from the real-time information collected by the system established under the program; (2) 511 Travel Information telephone service(s) providing to callers information that is derived from the real-time information collected by the system established under the program; (3) Regional ITS Architectures updated to reflect the systems established under the program; and (4) access to the data collected by the system established under the program in an established data exchange format through standard Internet protocol (IP) communications links.

Section 5508—Transportation Technology Innovation and Demonstration Program—Presents a two-part intelligent transportation infrastructure program (ITIP) to advance the deployment of an operational intelligent transportation infrastructure system, aid in transportation planning and analysis, and provide a basic level of traveler information.

Worker Protection

Section 1402—Worker Injury Prevention and Free Flow of Vehicular Traffic—Directs issuance of regulations to decrease the likelihood of worker injury and maintain the free flow of vehicular traffic by requiring workers whose duties place them on or in close proximity to a Federal-aid highway to wear high-visibility garments. *Federal Register* notice was issued in April 2006.

Conclusion

Economic prosperity and a population fast approaching 300 million have combined to produce record demand for personal and freight mobility. Transportation is woven into the economic fabric of the Nation as never before. But, continued economic growth is seriously threatened by congestion, the costs of which shippers, manufacturers, operators, and ultimately consumers all bear. The Administration's objective must be to reduce congestion, not simply to slow its increase. Congestion is not an insurmountable problem.

Without greater attention to operations, Americans will continue to waste many hours because of delay caused by recurring congestion, incidents, work zones, weather, and poor traffic control. Also, needless fatalities and injuries may result from unsafe conditions and crashes not being detected and countered in a timely fashion due to the absence of improved operational strategies. Through more effective operations, transportation system reliability, safety, and security can be improved and productivity increased.